DOCUMENT RESUME

ED 143 695 TM 006 461

AUTHOR Gholson, Barry
TITLE Developmental Stages, Hypothesis Theory, and Individual Differences.
PUB DATE Jun 77
NOTE 22p.; Paper presented at the NATO International Conference on Cognitive Psychology and Instruction (Amsterdam, Holland, June, 1977)

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Adolescents; *Age Differences; *Cognitive Development; Cognitive Style; College Students; Comparative Analysis; *Developmental Stages; Elementary School Students; Feedback; Individual Differences; *Learning Processes; Preschool Children; *Problem Solving
IDENTIFIERS *Piagetian Theory

ABSTRACT

In recent research, sequences of hypotheses observed during problem-solving have been categorized according to six hypothesis sampling systems that vary in efficiency. Three systems were characterized as strategies (focus, dimension check, hypothesis check) because they always lead eventually to solution. The remainder were called stereotypes (stimulus preference, position alternate, position perseverate) because they involve repeated manifestation of the same hypothesis (despite disconfirmation) and never lead to solution. Preliminary research revealed some striking developmental differences: Kindergarten children showed stereotypes in 90% of their problems; elementary-school children showed mostly dimension- and hypothesis-checking (65 to 80%) and little focusing (0 to 10%); college students showed focusing in half their problems and no stereotypes. These differences were compared to Piagetian stages of cognitive development. (Author/MV)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED143695

Developmental Stages, Hypothesis Theory, and Individual Differences

Barry Gholson

Memphis State University

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY

Barry Gholson

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER.

Paper presented at the NATO International Conference on Cognitive Psychology & Instruction, Amsterdam, June 1977.

TM006 461

Developmental Stages, Hypothesis Theory, and Individual Differences

Barry Gholson

Memphis State University

Recent research within the conceptual framework of hypothesis theory has demonstrated that sequences of hypotheses observed during problem solving may be fruitfully categorized according to the hypothesis sampling system observed during each problem (Gholson, Levine, & Phillips, 1972; Levine, 1975; Phillips & Levine, 1975). This analysis assumes that the subject attempts solution by sampling hypotheses according to some systematic plan. Six different systems have been delineated and observed with some frequency in previous research. Three of these, labeled "focusing," "dimension checking," and "hypothesis checking" were characterized as strategies, because they would, if followed perfectly, lead eventually to solution. The remaining three, "stimulus preference," "Position alternation," and "position perseveration" were labeled stereotypes, because they entail repeated manifestation of the same hypothesis despite disconfirmation and never lead to solution.

In considering the detection of each kind of system, for illustrative purposes, discussion is confined to bi-valued four-dimensional problems, and assumes that: (a) the subject always receives positive feedback on the first feedback trial and negative on the second and third; (b) stimulus pairs presented on feedback trials are arranged according to Levine's (1966) orthogonality criterion so that the first three such trials logically specify the solution; and (c) following each feedback trial the subject's hypothesis is known to the experimenter through the insertion of a set of blank (i.e., no feedback following response) trials (e.g., Eimas, 1969; Gholson et al. 1972; Levine, 1966, 1975). An example of such a blank-trial probe that may be used in bi-valued four-dimensional discrimination problems to infer which of the eight hypotheses the subject holds is presented in Fig. 1 (other kinds of

hypothesis probes may be used, of course, e.g., Kemler, 1972; Offenbach, 1974; Phillips & Levine, 1975).

The sequence of feedback trials and probes used to detect the various systems may be seen in Fig. 2. The subject using the focusing strategy begins the problem with all eight hypotheses, eliminates four incorrect hypotheses following the first feedback trial, two more following the second, and the final incorrect hypothesis following the third feedback. The hypothesis shown during the first blank-trial probe will be consistent with information from the first feedback trial, the second hypothesis will be consistent with information from both the first and second feedbacks, and the third hypothesis will be the solution. The latter is the only hypothesis that is consistent with feedback information from all three feedback trials. When such a sequence of hypotheses is observed on infers the focusing system.

Dimension checking is the second most efficient strategy. Here it is assumed the subject imagines a list of the dimensions, orders the two hypotheses onto each appropriately, then proceeds through the list checking one dimension at a time. Only one hypothesis per dimension (locally consistent at the time of selection) is shown, since the subject recognizes that its complement was logically disconfirmed at the time of selection. The subject might, for example, sample a locally consistent hypothesis from the color dimension, then if it is disconfirmed, reject the color dimension as containing the solution and try a locally consistent hypothesis from the size dimension, etc.

Hypothesis checking is the least efficient strategy. Here again it is assumed that the hypotheses are ordered by the subject into pairs on each dimension. He then goes through the list systematically, testing both hypotheses of each pair. He might, for example, try "large," then if it is disconfirmed try "small" before rejecting the size dimension as containing the

solution. He would then try a hypothesis from a second dimension, then its complement, etc.

When the stimulus preference stereotype is manifested the same hypothesis follows each feedback trial despite its repeated disconfirmation. It is as though the child "likes" a particular stimulus cue and, therefore, always chooses the stimulus complex that contains that cue regardless of the feedback consequences.

The two remaining stereotypes involve response sequences that indicate the child ignores the stimulus cues specified as possible solutions to the problem at hand. The child who manifests position alternation chooses one side then the other throughout the problem, e.g., left side, right side, left side, etc. Similarly, position perseveration involves responses to a single position throughout a problem, e.g., left side, left side, left side, etc. The construction of blank-trial probes in which each of the eight simple hypotheses corresponds to a 3-1 pattern of responses (i.e., three responses to one side and one response to the other, see Fig. 1) permits these position-oriented stereotypes to be unambiguously detected.

In addition to hypothesis sequences that may be classified as involving systems, subjects sometimes manifest hypotheses in unsystematic sequences. Since such sequences occur frequently under certain experimental conditions (see below), brief consideration of them is in order. Again assume that feedback is positive on the first feedback trial and negative on the second and third, etc. If, for example, the hypothesis sequence "large, red, small" or "large, red, large" were manifested the problem would be categorized as unsystematic, since the child tried one dimension (size) and rejected it, then a second (color), and then returned to the first again. In fact, fewer than 50% of the hypothesis sequences the subject could show in four-dimensional problems, if sampling were haphazard, correspond to any system category. While

unsystematic hypothesis sequences undoubtedly reflect a more sophisticated approach to the task than do stereotypic sequences, how they should be considered in relation to the strategy categories is presently unclear, since both subject and task variables can dramatically alter their occurrence (see below; Gholson & Danziger, 1975; Gholson, O'Connor, & Stern, 1976).

Preliminary research in which protocols of subjects of various ages were categorized according to the six system categories (Gholson et al. 1972; Gholson, Phillips, & Levine, 1973) revealed some striking and consistent developmental differences: college students showed focusing in half their problems and no stereotypes; elementary-school children (grades two through six) showed mostly dimension checking and hypothesis checking strategies (65 to 80%) and little focusing. Protocols of subjects of these age ranges are shown in Fig. 3.

Fig. 4 contrasts kindergarten children with second graders. As may be seen in the figure, kindergarten children showed about 90% stereotypes, while the second graders showed 80% strategies. The former showed mostly position alternation and the latter mostly dimension checking. This suggested the kindergarten children failed to differentiate the component cues of the discriminative stimuli (Gelman, 1969; Gibson & Gibson, 1955; Tighe & Tighe, 1966). Thus, a study using a transfer design in which kindergarten children received intensive stimulus-differentiation training prior to discrimination learning was conducted. Each child was presented with a series of 24 differentiation problems, six on each of four dimensions used in the transfer task. Half the children received feedback following each response during differentiation training and the remainder never received feedback during this phase of the experiment. In a second session each child received a series of standard four-dimensional problems (Fig. 1) with blank trials. The systems data are presented in Fig. 5: The group labeled "experimental" were those

who received feedback during differentiation training; the other group, labeled "control" in the figure, were those who did not. The data indicated that children in the experimental condition showed strategies in half their problems, while the controls showed only stereotypes. There was one puzzling finding, however, in that the experimentals showed unsystematic hypothesis sequences in about 30% of their problems (labeled "Random" in the figure), while such sequences had been observed in few problems in previous research.

These findings led Gholson and McConville (1974) to posit several kinds of underlying mechanisms that might account for the observed changes in information processing efficiency. One of these concerned the relationship between the various system categories and Piaget's descriptions of the cognitive capabilities of children at different stages of development (Inhelder & Piaget, 1958, 1964; Piaget, 1952, 1970). It was shown that preoperational children, who lack logical classification skills, reversible thought, etc. (about 2 to 6 years), could be expected to manifest only stereotypes or unsystematic hypothesis sequences; concrete operational children (about 6 to 12) have the capabilities to show dimension checking and hypothesis checking; but only formal operational children (older than about 12) could be expected to manifest focusing according to Piaget's theory. Recent studies have evaluated these predictions.

Two of these compared preoperational and concrete operational kindergarten children. Two conservation tasks were used to assess cognitive status, number and liquid quantity (Beilin, 1969; Gelman, 1969; Piaget, 1952). Kindergarten children were selected as a subject population for several reasons: First, it is well known that the transition from preoperational to concrete thought typically occurs in the age range five to seven years; second, it was necessary to hold the chronological ages and educational experiences of children assigned to the various groups as comparable as possible; finally, previous research

has shown that without special training unselected kindergarten children inevitably show either stimulus preference or position-oriented stereotypes.

In one study groups of preoperational and concrete operational children received stimulus differentiation training identical to that described above prior to discrimination learning (Gholson et al. 1976). Half the children of each cognitive level received feedback following responses during differentiation training and half did not. Results of the systems analysis are presented in Fig. 6. The differences were striking: Concrete operational children showed strategies in 75% of their problems under the experimental condition and 45% under the control condition, while the preoperational children showed about 90% stereotypes under both conditions. There were few unsystematic hypothesis sequences, however, so we were left with no explanation for the 30% observed in the earlier study. This suggested that transitional children, who were spefically excluded in research presented in Fig. 6 might have been responsible for the large proportion of unsystematic hypothesis sequences observed in the earlier study. Thus, a second study was conducted that used the exact conditions described above, but only involved transitional children. Performance of the children assigned to the experimental condition was intermediate between the preoperational and concrete children of Fig. 6. The controls performed almost identically to the preoperational children. Controls showed stereotypes in 86% of their problems and unsystematic sequences in 14%. The experimentals manifested stereotypes in 47%, strategies in 13%, and unsystematic sequences in 40% of their problems.

In order to examine the robustness of these differences, a second study that used vicarious learning procedures with preoperational, transitional, and concrete kindergarten children was recently conducted. Half the children at each cognitive level observed a model who illustrated the operations underlying the use of a dimension checking strategy while solving four short

discrimination problems that contained blank-trial probes. For the remaining children only the basic skills necessary to show any strategy were demonstrated (e.g., maintaining confirmed hypotheses, locally consistent sampling). Results of the systems analysis, which revealed a significant interaction between cognitive level and modeling condition are presented in Fig. 7. The concrete children showed strategies in half their problems, stereotypes in 35%, and unsystematic sequences in about 15% regardless of modeling condition. Among the transitional children, however, things were quite different. Those who observed the dimension checking strategy performed very similarly to the two concrete groups and the differences were not significant. The transitional children who observed only basic skills differed both from the former transitional group and from the concrete groups. They showed fewer strategies (11%) and more unsystematic hypothesis sequences (33%). This latter performance was very similar to the preoperational children exposed to rule instruction, who showed 15% strategies and 37% unsystematic sequences. The remaining preoperationals, however, manifested unsystematic hypothesis sequences in only 15% of their problems and stereotypes in 70%.

Research concerning the transition from concrete to formal thought has recently been reported by Shanna Richman (1975, 1976; Richman & Gholson, in press). As was noted above, many children begin the transition from concrete to formal thought during the age range 11 to 12 years, i.e., at about the time the average child is in the sixth grade (Inhelder & Piaget, 1958). It is known, though, that such children whow mostly dimension checking and little focusing under standard conditions (Gholson et al. 1972; Gholson & Danziger, 1975; Phillips & Levine, 1975). Richman (1975), however, reported a study in which sixth graders manifested a focusing strategy in over half their problems. As part of a larger study, second and sixth grade children were exposed to an observational learning procedure in which the operations involved in the use of

a focusing strategy were demonstrated and a summary rule provided. Following exposure to this observational condition, the sixth graders showed performance very similar to that typically observed among college students on each dependent measure and about 60% focusing. The second-grade children, on the other hand, following exposure to the same modeling procedure showed much poorer performance than is typically observed among children of this age range and little focusing (6%). In fact, they showed the worst performances we have ever observed among children of this age range.

Richman reasoned that many of her sixth-grade children were either formal operational or were transitional from concrete to formal thought, and exposure to the focusing model elicited the strategy because the requisite cognitive schemes were available to them. The second-grade children, however, were probably concrete operational. Following exposure to the modeling procedure they may have attempted to implement a focusing strategy, but since they lacked the cognitive schemes necessary to do so, they not only failed to focus but also showed a considerable decrement in performance compared to a basic skills condition used by Richman or compared to related research in which observational procedures were not used.

To evaluate these possibilities, Richman (1976) assessed same-age children as either concrete operational, transitional to formal operations, or formal operational according to Piaget's criteria (Inhelder & Piaget, 1958). Again she used several observational procedures, one of which involved the focusing system. She reported that formal operational children and those transitional to formal operations showed focusing in 55 to 60% of their problems following exposure to the focusing model. They showed dimension checking in the remainder of their problems. The concrete operational children exposed to the same observational learning procedures, however, showed focusing in only about 15% of their problems. Their modal strategy was dimension checking, but they

also showed some hypothesis checking and many unsystematic hypothesis sequences.

This research, then, provides very strong preliminary evidence for a stage conception of information processing performances within a cognitive developmental framework. Critics of stage conceptions of development (e.g., Brainerd, in press; Kessen, 1962) have legitimately stressed than any theory postulating an invariant sequence of qualitatively distinct stages must specify the behavioral implications of each stage, the rules that govern movement from one stage to the next, and the behavioral implications of the transition period. While little previous research effort has been directed at these questions within an information processing conception (cf. Beilin, 1976), the research described above has, at least in part, met these objections and provided some direction for future work. Present work is directed at illuminating qualitative changes in children's logical abilities and quantitative changes in the availability of various cognitive subprocesses involved in information processing both with normal and with learning disabled and mentally retarded children.

References

Beilin, H. Stimulus and cognitive transformation in conservation. In D. Elkind and J. H. Flavell (Eds.), Studies in cognitive development: Essays in honor of Jean Piaget. New York: Oxford University, 1969.

Beilin, H. Constructing cognitive operations linguistically. In H. W. Reese (Ed.), Advances in child development and behavior. Vol. 11. New York: Academic Press, 1976.

Brainerd, C. J. "Stege," "structure," and developmental theory. In G. Steiner (Ed.), The psychology of the twentieth century. Munich: Kindler, in press.

Eimas, P. D. A developmental study of hypothesis behavior and focusing. Journal of Experimental Child Psychology, 1969, 8, 160-172.

Gelman, R. Conservation acquisition: A problem of learning to attend to relevant attributes. Journal of Experimental Child Psychology, 1969, 7, 167-187.

Gholson, B., & Danziger, S. Effects of two levels of stimulus complexity upon hypothesis sampling systems among second and sixth grade children. Journal of Experimental Child Psychology, 1975, 20, 105-118.

Gholson, B., Levine, M., & Phillips, S. Hypotheses, strategies, and stereotypes in discrimination learning. Journal of Experimental Child Psychology, 1972, 13, 423-446.

Gholson, B., & McConville, K. Effects of stimulus differentiation training upon hypotheses, strategies, and stereotypes in discrimination learning among kindergarten children. Journal of Experimental Child Psychology, 1974, 18, 81-97.

Gholson, B., O'Connor, J., & Stern, I. Hypothesis sampling systems among preoperational and concrete operational kindergarten children. Journal of Experimental Child Psychology, 1976, 21, 61-76.

Gholson, B., Phillips, S., & Levine, M. Effects of the temporal relationship of feedback and stimulus information upon discrimination-learning strategies. Journal of Experimental Child Psychology, 1973, 15, 425-441.

Gibson, J. J., & Gibson, E. F. Perceptual learning: Differentiation or enrichment? Psychological Review, 1955, 62, 32-41.

Inhelder, B., & Piaget, J. The growth of ligical thinking from childhood to adolescence. New York: Basic Books, 1958.

Inhelder, B., & Piaget, J. The early growth of logic in the child. New York: Norton, 1964.

Kemler, D. G. A developmental study of hypothesis-testing in discrimination learning tasks. Unpublished Ph.D thesis, Brown University, 1972,

Kessen, W. "Stages" and "structure" in the study of children. In W. Kessen and C. Kohlman (Eds.), Thought in the young child. Monographs of the Society for Research in Child Development, 1962, 28, (Whole No. 83).

Levine, M. Hypothesis behavior by humans during discrimination learning. Journal of Experimental Psychology, 1966, 71, 331-338.

Levine, M. A cognitive theory of learning: Research on hypothesis testing. Hillsdale, N. J.: Lawrence Erlbaum Associates, 1975.

Offenbach, S. I. A developmental study of hypothesis testing and cue selection strategies. Developmental Psychology, 1974, 10, 484-490.

Phillips, S., & Levine, M. Probing for hypotheses with adults and children: Blank trials and introtacts. Journal of Experimental Psychology: General, 1975, 104, 327-354.

Piaget, J. The child's conception of number. New York: Humanities, 1952.

Piaget, J. Piaget's theory. In P. H. Mussen (Ed.), Carmichael's manual of child psychology. Vol. 1. New York: Wiley and Sons, 1970.

Richman, S. Effects os strategy modeling and age upon information processing among elementary-school children. Unpublished Ph.D thesis, Hunter College

of the City University of New York, 1975.

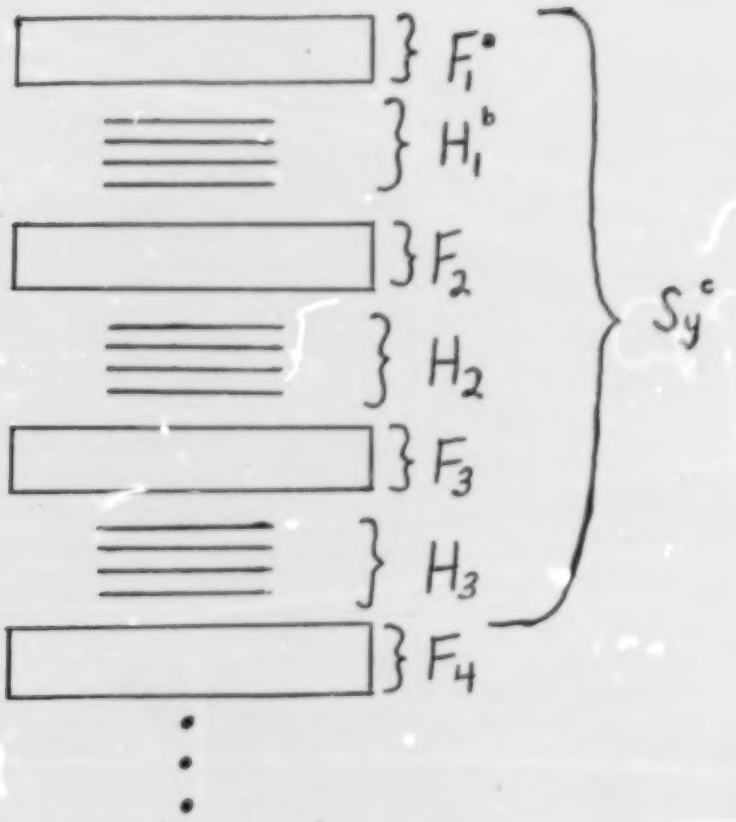
Richman, S. Piagetian Stage, strategy modeling, and problem-solving strategies. Paper presented at the American Psychological Association meetings, Washington, D. C., 1976.

Richman, S., & Cholson, B. Strategy modeling, age, and information-processing efficiency. Journal of Experimental Child Psychology, in press.

Tighe, L. S., & Tighe, T. J. Discrimination learning: Two views in historical perspective. Psychological Bulletin, 1966, 66, 353-370.

BLACK
X
LINE UP
LARGE
HYPOTHESIS
T
X
T
X
X
T
T
X
WHITE
T
LINE DOWN
SMALL
HYPOTHESIS

Fig. 1



[a] F = Feedback trial

[b] H = Hypothesis; inferred from a series of four consecutive blank trials

[c] Sy = Hypothesis sampling system; inferred from a series of three feedback trials and the H that follows each

Fig. 2

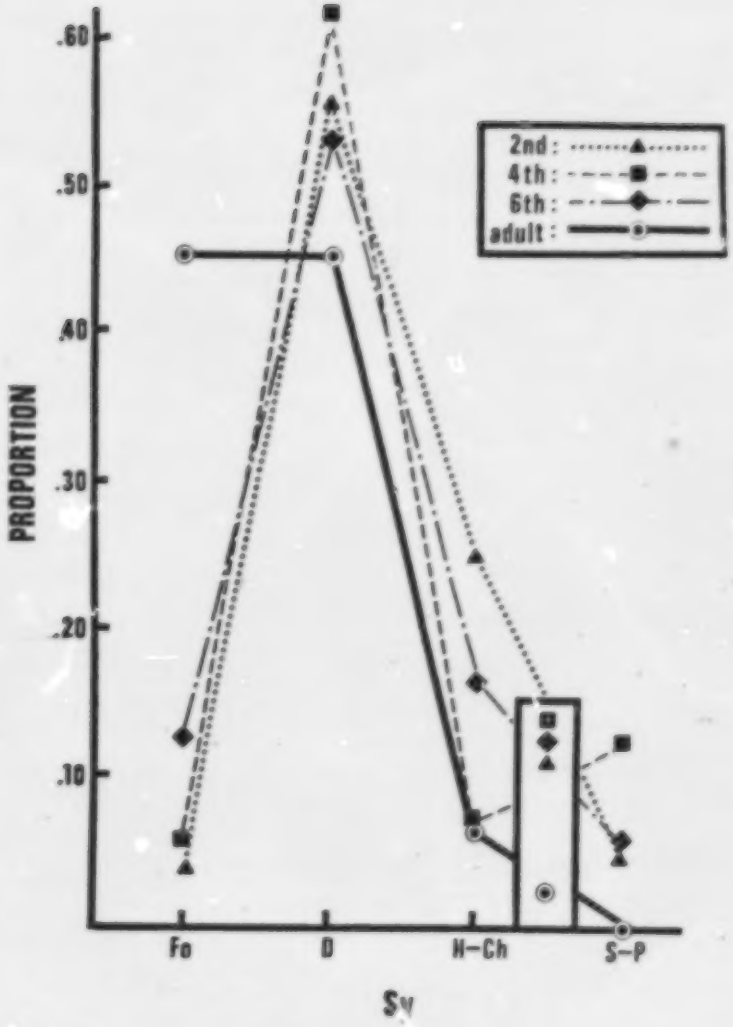


Fig. 2

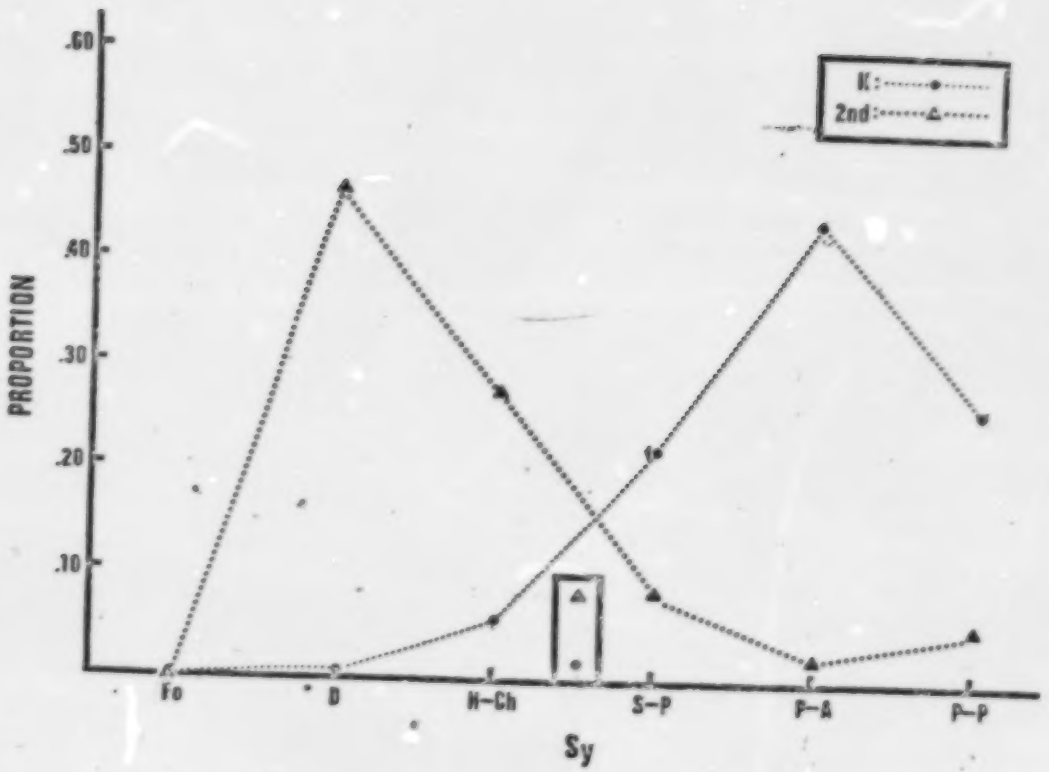


Fig. 4

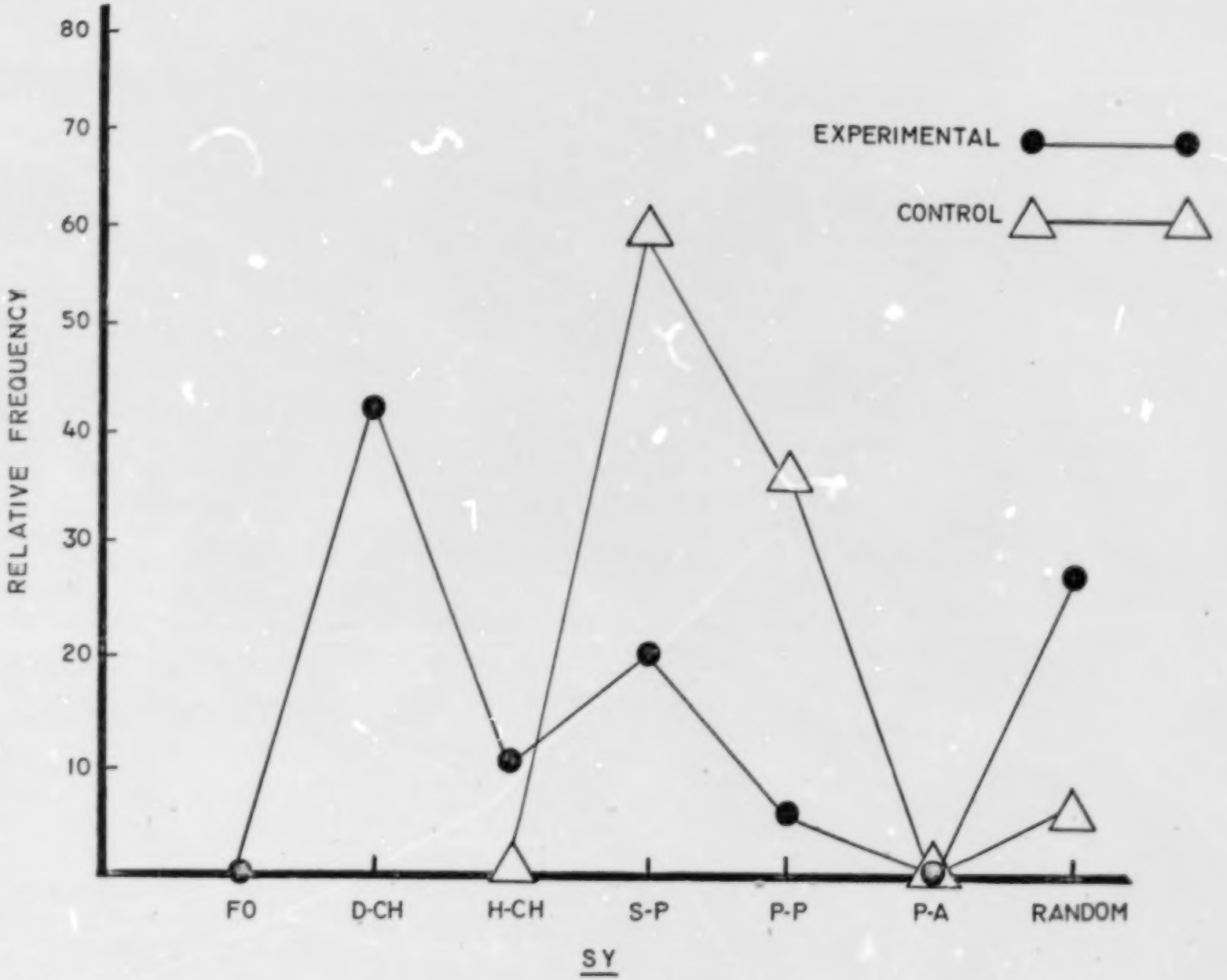
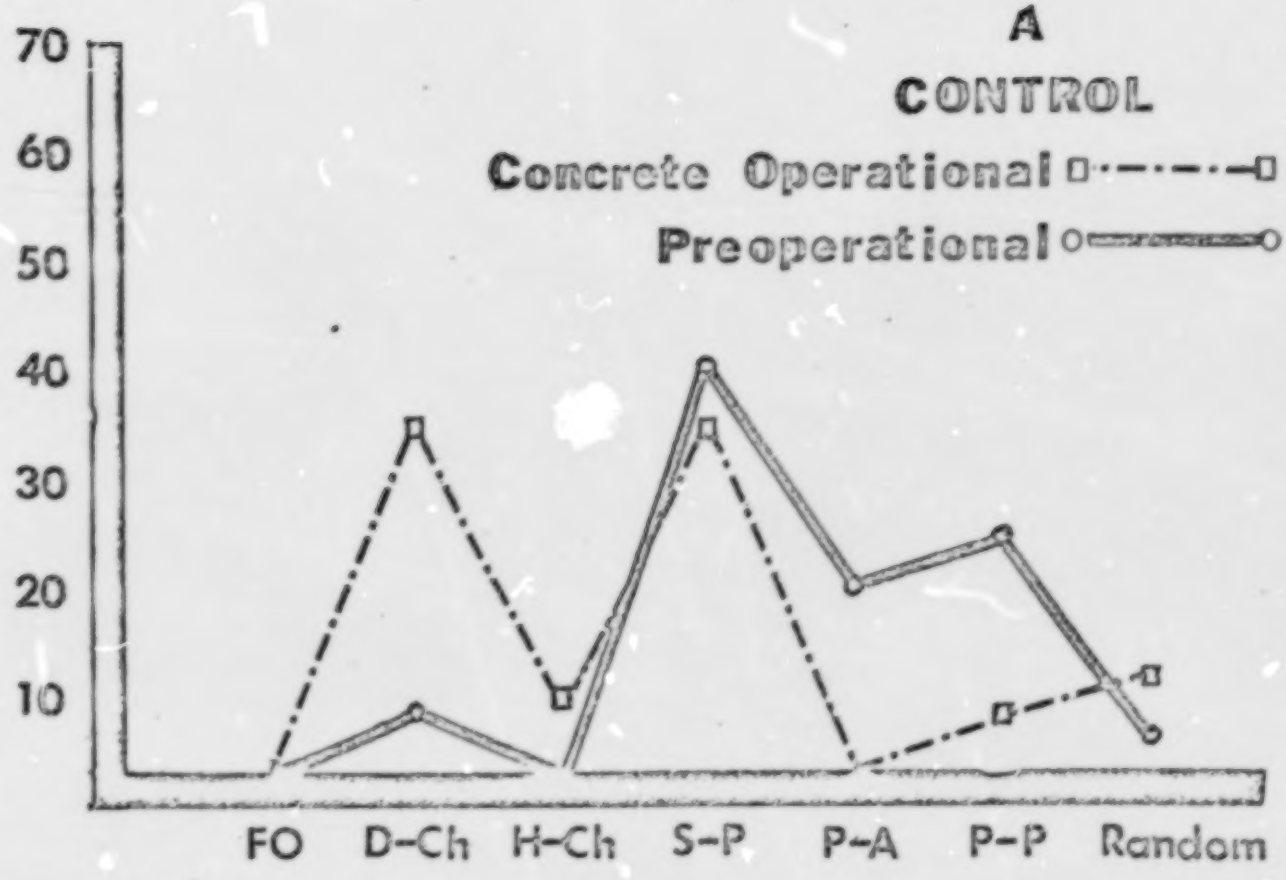
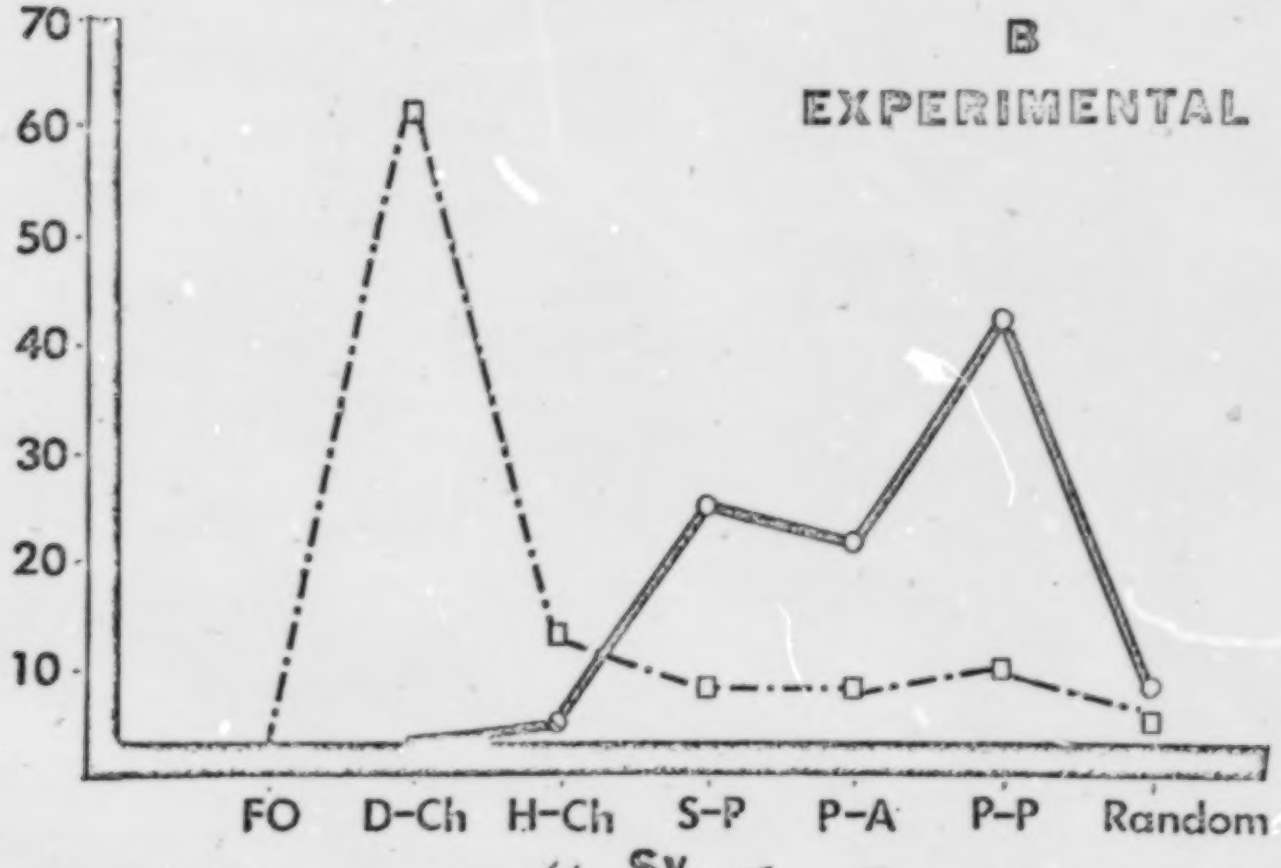

80
70
60
50
40
30
20
10
RELATIVE FREQUENCY
EXPERIMENTAL
CONTROL
FO
D-CH
H-CH
S-P
P-P
P-A
RANDOM
SY

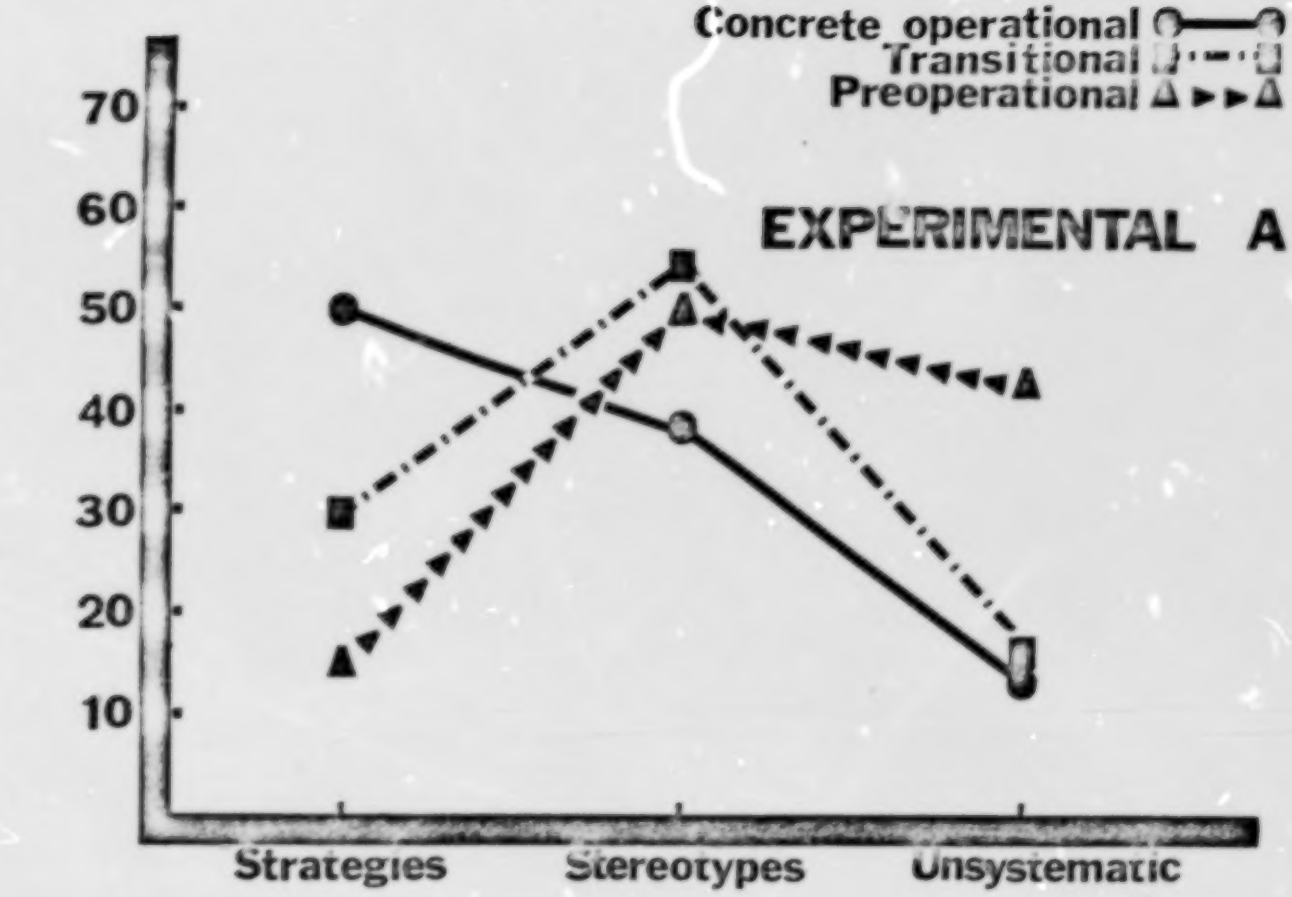
Fig. 5

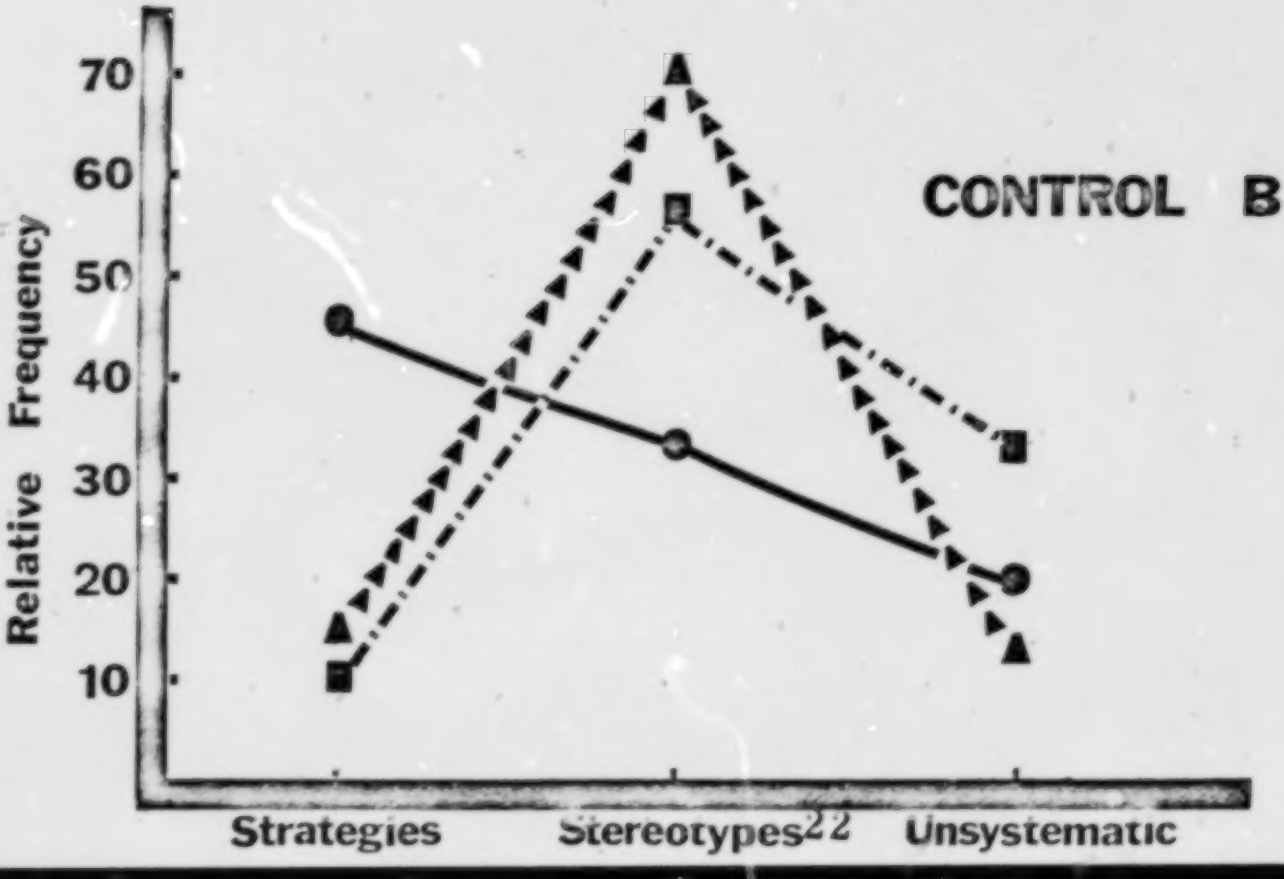

A
CONTROL
Concrete Operational
Preoperational
70
60
50
40
30
20
10
FO
D-Ch
H-Ch
S-P
P-A
P-P
Random


B
EXPERIMENTAL
70
60
50
40
30
20
10
FO
D-Ch
H-Ch
S-P
P-A
P-P
Random

21 Sy

Fig. 6


Concrete operational
Transitional
Preoperational
EXPERIMENTAL A
70
60
50
40
30
20
10
Strategies
Stereotypes
Unsystematic


CONTROL B
Relative Frequency
70
60
50
40
30
20
10
Strategies
Stereotypes
Unsystematic